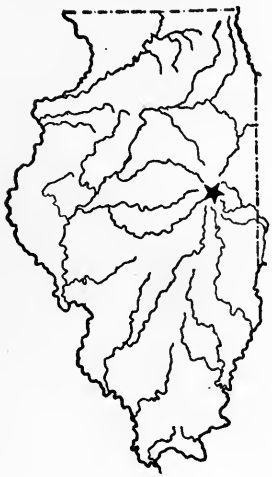
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 112

THE COTTONY MAPLE SCALE IN ILLINOIS

By S. A. FORBES
State Entomologist



URBANA, JANUARY, 1907

Summary of Bulletin No. 112.

1. History of the cottony maple scale in Illinois, and especially recent history in and about Chicago. Page 343.

2. Injurious effects of infestation of trees. Page 345.

3. Trees most likely to be injured are the soft maple, box-elder, and the basswood. Other trees and shrubs liable to injury. Page 346.

4. Life history of the insect. Single brooded. Males perish before winter; females survive, partly grown, on twigs and smaller branches. Page 347.

5. The hatching period is from June 15 to July 20; the beginning varies as much as two weeks, according to latitude and weather. Page 349.

6. Summer experiments with kerosene emulsion. One application of 10 per cent. emulsion, at middle of hatching period, killed about two thirds of the scales, and two applications, at middle and end of hatching period, killed about four fifths. Page 349.

7. Winter insecticide measures more effective, a single treatment with 19 or 20 per cent. emulsion killing from 86 to 91 per cent. of the insects. Page 353.

8. Diseased or weakened trees liable to serious injury by the kerosene sprays. Page 355.

9. Protection of roots against excess of insecticide suggested. Page 356.

10. Successful use in Colorado of a winter spray containing only one sixth of kerosene. Page 356.

11. Insect enemies of the scale which have been found most effective for its destruction. Page 357.

12. Summary and general discussion. Page 358.

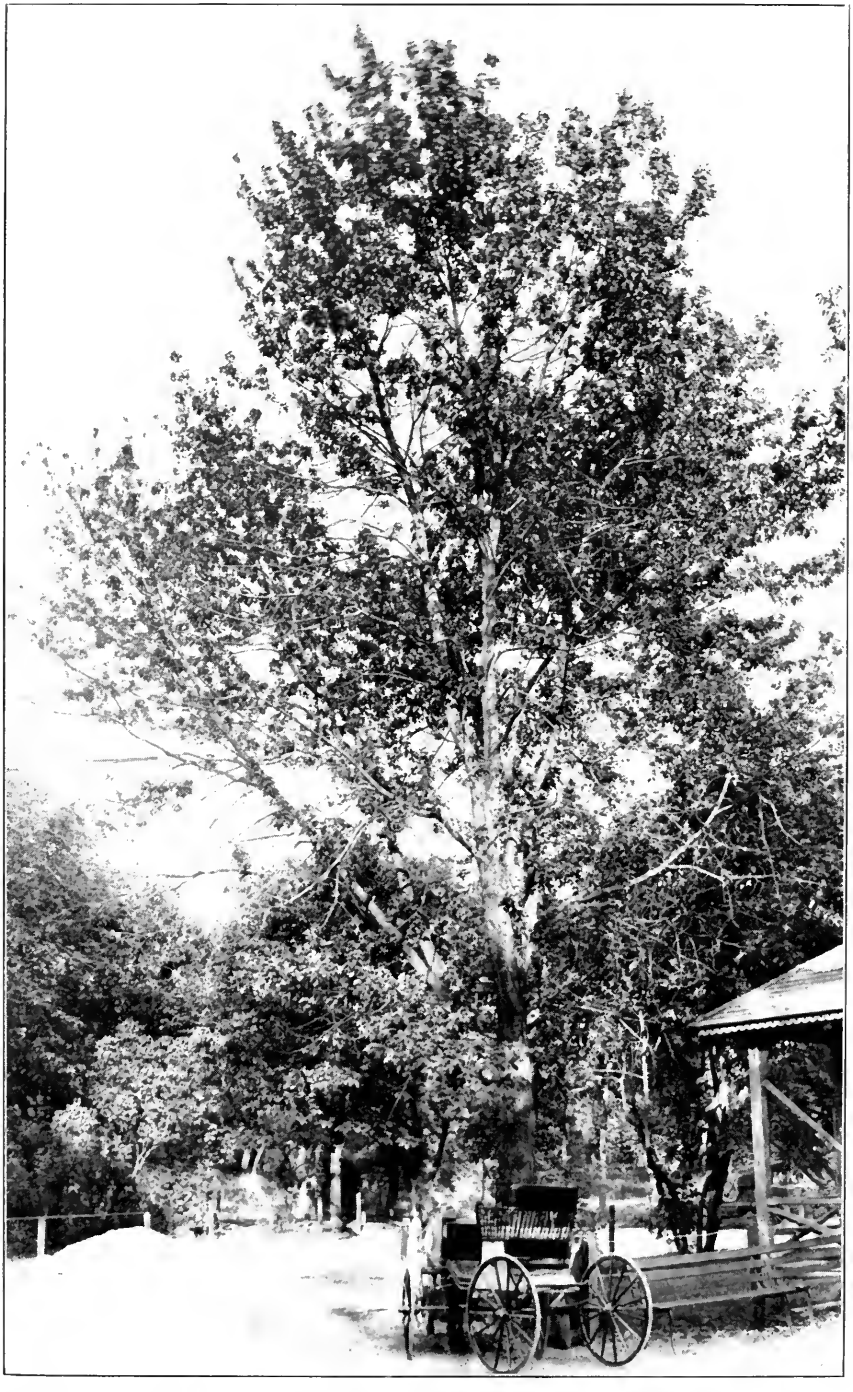


PLATE 1. SOFT MAPLE TREE SPRAYED WITH 20 PER CENT. KEROSENE EMULSION JANUARY 19, AND PHOTOGRAPHED JUNE 23, 1906.
ORIGINALLY A SOUND TREE.

THE COTTONY MAPLE SCALE IN ILLINOIS.

The cottony maple scale* is a native insect parasite of the soft maple†, rarely if ever injurious to the scattering trees of this species growing in natural forests, but so destructive to them, and to other ornamental trees as well, where these are grown in rows or groups along streets or in parks and on private lawns, that its control has become an object of primary importance to all owners and lovers of some of our most beautiful and popular American trees. In and about Chicago especially, it has destroyed, within the past five years, thousands of trees, beautiful and valuable in themselves, and still more highly valued because of the associations attached to them. To do our best to save these noble but helpless products of nature from a slow and unsightly death by parasitic disease, must be the welcome duty of all who appreciate the significance of trees in the life of the people, and especially of those who live in our larger cities.

The history of this insect in Illinois since 1867 exhibits successive periods of abundance and of scarcity, each averaging about four or five years for the state as a whole. That is, throughout some considerable part of the state, and often over most of it, the maple scale has been injuriously abundant once in eight or ten years, and its period of abundance has lasted, as a rule, about half this time. In any given locality, however, it has usually been injurious for a much shorter time, often for not more than one or two years. The cessation of its injuries and its virtual disappearance from the trees infested by it have seemingly been due almost wholly to the agency of its insect enemies.

An exception to these statements is presented by the existing outbreak of this insect in northeastern Illinois, and especially in Chicago and its suburbs to the north and west. Here, as shown by observations of assistants of the office who have been repeatedly sent through the park and boulevard systems of Chicago for an investigation of insect injuries to shade trees and other ornamental vegetation, it has certainly been destructively numerous since 1901. Indeed, according to information locally given to Mr. H. E. Weed, of Chicago, it has been continuously injurious over some parts of this area since 1886. This general persistence of an injurious infestation within the same district for so long a period is due to the

*Pulvinaria innumerabilis. †Acer saccharinum.

FIG. 1. A Soft Maple Twig badly infested with adults of the Cottony Maple Scale. About natural size. (J. B. Smith.)

failure of the insect enemies of this scale to multiply at a sufficient rate to check its rapid increase, and this is possibly the consequence of an unfavorable effect of a city environment, although there is some reason to suppose that the cottony maple scale has here extended northward into a latitude more favorable to itself than to the insect enemies which commonly hold it in check.

Although no attempt has been made to define the present area of destructive infestation in Illinois, this scale was reported to me during 1905, in the current correspondence of the office, as locally abundant in fifteen counties, namely, Winnebago, Lake, McHenry, Cook, Dupage, Kane, DeKalb, Ogle, Bureau, and Henry in northern Illinois; Woodford, DeWitt, Sangamon, and Montgomery in central Illinois; and Marion in the southern part of the state. Doubtless the actual area infested by it was much more general than this list would indicate.

The injurious effect of a severe and long-continued drain by the cottony maple scale on the vitality of trees infested by it is unquestionable. Many thousands of soft maple, linden, box-elder, and elm trees in northeastern Illinois are now dead or dying, or have been disfigured by the death of large branches, because of injuries by this insect, and large numbers of such trees have been removed. Private citizens, town boards, and park commissioners have become deeply concerned, and numerous inquiries and appeals for aid have come to this office during the past three years. A lack of available funds has, however, prevented as active a participation in the work of practical experiment and insecticide operation as might reasonably have been expected of the Entomologist's office, and I have been obliged to content myself, in the main, with improving the opportunity to observe, and incidentally to assist, the work of official bodies and private parties for the control of this pest.

I am particularly indebted to Mr. Reuben H. Warder, Superintendent of Lincoln Park, who has kept me acquainted with his work against this and other scale insects, and has made it possible for us to follow his operations in detail to their final results. I am also under obligations to Mr. O. C. Simonds, Superintendent of Graceland Cemetery, for similar privileges. Our field observations have been mainly made by Dr. J. W. Folsom, Associate in Entomology at the University of Illinois, and by Mr. E. O. G. Kelly and Mr. C. A. Hart, serving as assistants to the State Entomologist. Dr. Folsom also managed a small spraying experiment for me at Graceland Cemetery in 1905.

The present article, in the preparation of which I have had the valued assistance of Mr. Hart, is intended to give a brief account of

the insect, to review the attempts made to destroy it by means of summer and winter sprays, and to present practical instructions for its mastery where it is still present in destructive or threatening numbers.

A comprehensive article on the insect, prepared by Dr. L. O. Howard, appeared in 1900 in Bull. 22 of the U. S. Bureau of Entomology, and Circular 64 of that Bureau gives a brief popular account of it and of measures to be taken for its destruction. This paper was prepared with special reference to the Chicago situation of 1905. In Bull. 52 of the Bureau, published in 1905, is a paper by Mr. H. E. Weed describing his experiences in spraying against this scale in Chicago, and Mr. S. A. Johnson has reported on some experiments in Denver, Col., with a winter insecticidal treatment. The last-mentioned author has this year made the species the subject of Bull. 116 of the Colorado Agricultural Experiment Station, in which a summer treatment is especially discussed.

Food Plants.

The soft maple (*Acer saccharinum*) is the tree most generally and heavily infested by this insect. The hard maples, on the other hand, are infested but slightly if at all. The box-elder is also greatly subject to injury, and next to this, perhaps, the linden or basswood. Among the other trees and woody plants often more or less injured, are the elm, honey-locust, black locust, black walnut, sumac, willow, poplar, beech, hawthorn, bittersweet, grape-vine, and Viriginia creeper. Dr. Folsom found mature egg-laying females on the horse-chestnut, honeysuckle, dogwood, trumpet-creeper, mulberry, snowberry, smoke-tree, Spiræa, false syringa (*Philadelphus*), and Wistaria. Oak, ash, and catalpa are not infested in northern Illinois, but injury to oak is reported from Georgia. According to S. A. Johnson, the pear is most liable to injury among the fruit-trees, and apple, plum, and peach are sometimes infested. Serious damage to fruit-trees is, however, very unlikely. The migrating young, which are often washed from trees by rain, or blown off in considerable numbers, may maintain themselves for a time on a great variety of woody and herbaceous plants, those on the latter, of course, perishing with the advent of frosts.

THE LIFE HISTORY OF THE INSECT.

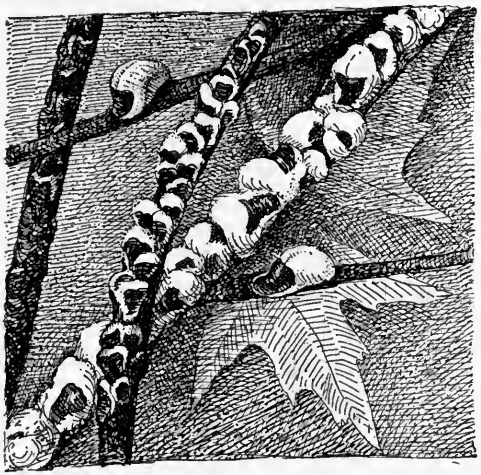


FIG. 2. The Cottony Maple Scale, adult females on twigs. Natural size. (Howard, U. S. Department of Agriculture.)

In early summer this scale, when very abundant, coats the under side of heavily infested limbs with a thick layer of cotton-like waxy masses (Fig. 1, 2), each projecting from beneath a brown cap or scale—the flat body of the mature female. This "cotton" is secreted and the eggs are deposited within it in late May or early June in the latitude of central Illinois, but usually one or two weeks later in the Chicago district.

Something over 3000 eggs are usually laid by each female, the number ranging, in our counts, from 2856 to 3863, with an aver-

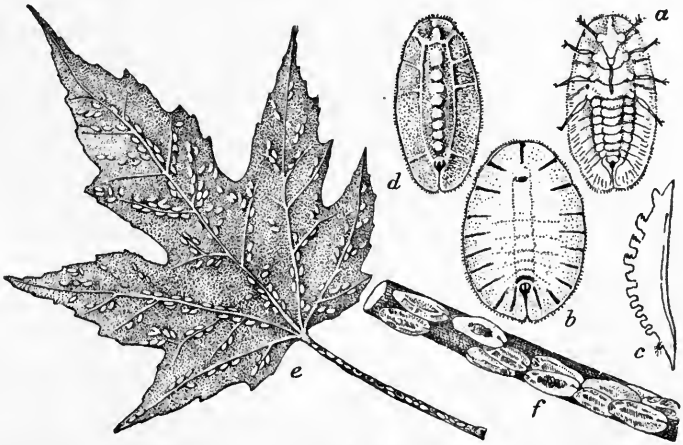


FIG. 3. The Cottony Maple Scale, immature stages: *a*, newly hatched young, under side; *b*, *c*, young female, top and side views; *d*, young male; *e*, *f*, young on leaf and leaf-stem. Natural size shown in *e*. (Howard, U. S. Department of Agriculture.)

age of 3410. These eggs ordinarily hatch in June in central Illinois, in early July in the northeastern part of the state, or later if the weather of the time is unfavorable. Virtually all are hatched, as a rule, by the end of July. The young insects may crawl out on the leaves and establish themselves beside the principal veins on both

surfaces of the leaf, but most abundantly beneath, or else may locate upon the twigs. At this season (Fig. 3) they present the appearance of small, inconspicuous, waxy, elongate-oval scales, applied closely to the leaf. They are usually motionless, but have nevertheless minute legs still capable of service, but invisible unless the insect is turned over. Inserting their tiny beaks into the tissue of the leaf, they suck out the sap, and when the supply of food is large they give off the excess in the form of a sticky fluid, the so-called "honey dew," which moistens the surface of the lower leaves and falls on the plants beneath the tree. Under this large and constant withdrawal of sap the leaves turn pale or yellowish, and may fall off prematurely, with the effect sometimes to kill the larger branches or even the entire tree.

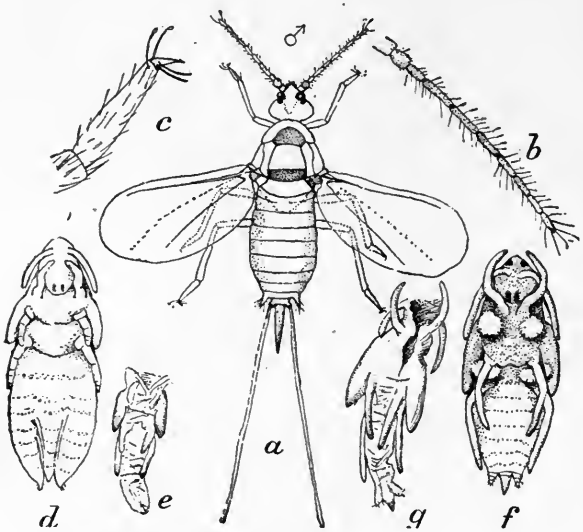


FIG. 4. Male of Cottony Maple Scale: *a*, adult; *b*, *c*, an antenna and leg enlarged; *d*, *e*, second stage of pupa and its cast skin; *f*, *g*, true pupa and its cast skin. All greatly enlarged. (Howard, U. S. Department of Agriculture.)

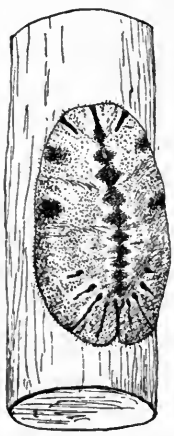


FIG. 5. The Cottony Maple Scale: adult female in spring, just before the formation of the cottony egg-sac. (Howard, U. S. Department of Agriculture.)

The male bark-lice beneath the scales on the leaves reach maturity the same season, and transform to tiny gnat-like insects (Fig. 4) with a pair of delicate wings. They pair with the partly grown females on the leaves, and die at the approach of winter. Before the fall of the leaf in autumn the young females collect on the under side of the smaller branches, where they spend the winter in a more or less dormant condition with their beaks inserted in the wood. They complete their growth in spring (Fig. 5), and in due time produce the so-called "cotton," within which the eggs are imbedded.

THE HATCHING PERIOD.

As the newly hatched young are especially susceptible to the petroleum insecticides, which act by contact, a definite knowledge of the hatching period has an important practical value. In central Illinois this period extends approximately from June 15 to July 20. In and about Chicago it commonly begins about two weeks later, and continues for a period of three weeks, this retardation being apparently due to the higher latitude and to the neighborhood of Lake Michigan. In 1905, for example, Dr. Folsom found that the young began to appear in Chicago about July 1, and were all out by July 21 or a few days later, but that thirty miles west of the city, hatching began about June 20. Mr. H. E. Weed reports, in Bull. 52 of the U. S. Bureau of Entomology, that in 1904 scarcely any eggs had hatched in Chicago by June 25, but that the young appeared rapidly under the influence of a few days of warm weather about July 10. The recorded dates for Colorado approach those given for Chicago. In Washington, D. C., according to Dr. Howard, hatching of the eggs begins usually in late May or early June, and continues into July and sometimes to the beginning of August.

The period varies, in short, as to its beginning time, with the advancement of the season, and once begun, the rapidity of the hatching will depend, other things being equal, on the warmth of the weather. It is also influenced locally by the amount of foliage on the trees, the eggs hatching later and more slowly in a dense tree-top than in one more open to the sun.

SUMMER INSECTICIDE MEASURES.

Owing to the manner in which these insects obtain their food—that is, by sucking the sap through a tubular beak—they are not susceptible to poisoning by way of their food, and the only insecticides available against them are those which kill by contact, and of these the kerosene mixtures have thus far been found the most useful. The most satisfactory of these is the common kerosene emulsion, made by thoroughly and intimately mixing a good grade of kerosene with one third its volume of a strong soap-suds, and diluting with water according to the time of the year when used. Precise directions for preparing and applying this emulsion may be found in the general summary at the end of this paper.

The use of this insecticide for the maple scale dates from experiments made by me in 1884, intended to test the effect of kerosene emulsion on the newly hatched young, and described in the Fourteenth Report of the Illinois State Entomologist. They showed

that practically all these may be killed by dipping the infested leaves in dilute emulsions (those used varying in content from 2½ to 10 per cent. of kerosene), unless the application be delayed too long after hatching. When the young are a week or two old they are partially protected by a waxy covering against the action of the oil. The test of death used was a thoroughly reliable one. The young were at this time so small and transparent that the action of the heart could be readily seen under a microscope, and the cessation of this action was the mark of death depended upon. As the maple scale disappeared from my neighborhood in 1885, no further experiments were made at that time.

In 1904 the Commissioners of the North Shore Park District, above Chicago, of which Robert W. Vasey was president, engaged Mr. H. E. Weed, of Chicago, to treat one hundred and twenty soft maples and box-elder trees in their charge, along the boulevards, for the destruction of the cottony maple scale. A report of this treatment by Mr. Weed was printed in Bull. 52 of the U. S. Bureau of Entomology. The results of his work were submitted to me for examination in August and September, 1904, by Mr. Vasey, who sent me leaves from the trees which had been treated with a 12 per cent. emulsion.

The scale insects on these leaves were carefully examined at my office by Mr. Hart, who found that out of 1781 scales 610 were alive and 1171 were dead.* Practically all the living scales were on the under surface of the leaves, only 1 per cent. of those on the upper surface being still alive. The ratio of the dead to the living on these leaves was 60 per cent.; but as it seemed likely that some scales were dead before the spray was applied, Mr. Vasey sent me, for comparison, at my request, leaves from infested trees not treated. An examination of these untreated leaves showed that 22 per cent. of those on the upper surface were dead and 4 per cent. of those on the lower surface. Making the necessary correction, it was found that 57 per cent. of the scales alive when the trees were sprayed had been killed by the treatment. The spray thus tested was applied August 29.

According to Mr. Vasey, the insects had hatched very slowly that year, owing to the backward season, but had been in condition for treatment with the kerosene spray for some three or four weeks preceding. It will be seen, consequently, that the treatment was too late to produce the full effect upon the young. Further

*The young insects were by this time so opaque that the movements of the heart could no longer be seen; but it was found that living individuals, when displaced and inverted, made slow movements of the legs, and that dead individuals were not only motionless but paler and often discolored, and usually more or less dried up.

PLATE 2. SOFT MAPLE TREE SPRAYED WITH KEROSENE EMULSION JANUARY 18, AND PHOTOGRAPHED JUNE 23, 1906.
ORIGINALLY WEAK, WITH TRUNK AND LARGER LIMBS DECAYED AND HOLLOW.

work showed that a 15 per cent. emulsion was injurious to the tree, taking nearly all the leaves from the box-elders and the lindens, and half those from the soft maples. In this same year (1904) Mr. S. A. Johnson, of the Col. Agricultural Experiment Station, made a number of laboratory experiments with the summer treatment of this insect, reaching the conclusion that after the young are a week or ten days old they are not easily killed by the kerosene emulsion, but that before reaching this age they may be effectively treated by sprays of as low a strength as 5 per cent.

The following year (1905) Dr. J. W. Folsom, of the University of Illinois, made for me a series of experiments, opportunity for which was provided by the courtesy of Mr. O. C. Simonds, Superintendent of Graceland Cemetery.

A 10 per cent. emulsion of kerosene was applied to several trees of medium size with the use of a Bordeaux nozzle on an extension-pole. A solid stream was first directed against the egg-masses in order to loosen and soak them, after which a very fine spray was applied as thoroughly as possible to both sides of the leaves. A solution of whale-oil soap (one pound to six gallons of water) was applied to an eighth tree by the same apparatus and with the same care.

The effect of the spray was tested by counting both dead and living scales on twenty-five leaves picked at random from different parts of each tree, one series of counts being made just before the spray was applied and another as soon as possible after it had dried away and taken effect. Among the trees receiving the 10 per cent. emulsion of kerosene were one tree sprayed July 3, at the beginning of the hatching period of the scale, one treated July 11, at about the middle of this period, three treated July 19 and 20, at the end of the period, and one treated twice, once at the middle and once at the end. The tree receiving the soap solution was sprayed July 19—that is, at the end of the hatching season.

Four hundred and eighty-four thousand scales, borne by four hundred and fifty leaves from these various trees, were critically examined, and classified as either living or dead. The ratio of benefit—the percentage, that is, of scales actually killed by the spray—was determined in all cases by eliminating from the calculation the scales dead at the beginning of the experiment, and figuring the percentages only on the number of scales alive when the spray was applied. The following table gives the essential data and results of these experiments.

EFFECTS OF EXPERIMENTAL SUMMER SPRAY.

Treatment		No. of trees	Leaves examined	Scales examined	Per cent. killed by spray
Insecticide	Part of hatching period				
10 per cent. Kerosene	Beginning	1	75	48,789	33
10 per cent. Kerosene	Middle	1	50	19,425	64
10 per cent. Kerosene.	End	3	150	281,271	68
10 per cent. Kerosene	Middle and end	1	100	57,179	82
1 lb. Whale-oil Soap to 6 gal. water	End	1	75	77,171	43

From this it will be seen that 75 leaves bearing 49,000 scales were examined from the tree sprayed July 3, and that only 33 per cent. of the scales on this tree had been killed. In this case a first inspection was made ten days after the spray was applied, and a second, seven days later. The trees sprayed once July 11—at the middle of the hatching period—and from which 50 leaves bearing 19,000 scales were examined, showed a ratio of benefit of 64 per cent.; that is, 64 per cent. of the scales alive when the spray was applied, were dead a few hours later. In other words, by postponing the treatment from the 3d to the 11th of the month the effect of it had been nearly doubled. A similar but somewhat greater effect was produced by single treatments given July 19 and 20, when the greater part of the eggs were already hatched, 68 per cent. of the living scales among the 281,000 borne by the 150 leaves examined being thus killed. The most effective treatment was a double spraying, one application at the middle and the other about the end of the hatching period, which, as shown by an examination of 57,000 scales from 100 leaves of the tree so treated, killed 82 per cent. of the scales alive when the tree was sprayed. That is, the effect of the operation had been increased approximately 28 per cent. by the second spraying.

A comparison of the scales on the two surfaces of the leaves showed that the ratio of those killed on the lower surface was only 72 per cent. that of those killed on the upper surface. This was doubt-

less due in part to the fact that the upper surface of the leaf is more exposed to the spray than the under, and possibly also in part to the inferior vitality of the scales on the more exposed surface of the leaf. That there is really such a difference is shown by the difference in ratios of dead to living on the two leaf surfaces before the trees were sprayed. The general average of all the counts is 3.6 per cent. of dead on the upper surface of the leaf and 2 per cent. on the lower.

In the tree sprayed July 3 the effect on the scales on the upper and the lower parts of the top of the tree was brought into comparison by examining the scales on 25 leaves from each. Twenty-two per cent. of the scales on the upper leaves had been killed and 35 per cent. of those on the lower, the ratio of killed being more than half as great again for the lower leaves as for the upper. This is doubtless due, at least in part, to the greater and more prolonged effect produced on the lower leaves by the drip from the upper part of the top.

We may infer from these experiments that two sprayings with a 10 per cent. kerosene emulsion, one applied at the middle and the other at the end of the hatching period, separated, that is, by an interval of about ten days, will produce the maximum effect on the scale, and that they may be expected to destroy 80 per cent. or more of the insects then alive. It should be added that no harm to the tree was done by any of these treatments except a slight burning at the edges of the leaves of the tree which was twice sprayed. This appearance of injury was perhaps due to humid weather which followed the first treatment, delaying the evaporation of the kerosene. Two trees were treated July 11 with a 10 per cent. kerosene emulsion, at a time and place when rain was falling with a result to diminish by half the killing effect of the spray.

The cost of the 10 per cent. emulsion used in these experiments was 4.3 cents per gallon, and the trees were large enough to require three or four gallons each for a single treatment.

The whale-oil soap solution applied at the end of the hatching period had about two thirds the effect of the corresponding kerosene treatment, as shown by a comparison of the results of the data already given for the latter with those derived from an examination of 77,000 scales on 75 leaves taken from the tree treated with the former insecticide.

WINTER INSECTICIDE MEASURES.

Winter spraying, when the trees are bare, has the advantage that stronger insecticides may be used, and that less than half as

much liquid is needed to the tree. On the other hand, the scales are now larger and firmer and more resistant to the insecticide than in summer.

The extensive operations against this scale by the Superintendent of Lincoln Park during the winter of 1905-06 were followed by one of my assistants, Mr. E. O. G. Kelly, sent repeatedly to Chicago for this purpose. Nearly every tree and shrub in this park infested by the maple scale was sprayed under the immediate supervision of Mr. R. W. Braucher. Two thousand six hundred and seventy-three trees and 4456 shrubs were sprayed, nearly half the trees ranging from large to very large, and the remainder from small to medium. The materials used in this treatment were 4153 gallons of kerosene and 3074 pounds of soap, made up in 20,800 gallons of kerosene emulsion. The cost of the latter was approximately 2 cents a gallon. With the outfit used, a Fairbanks-Morse power sprayer with double "Vermorel" nozzles, it required, on an average, five minutes to spray each tree, or an hour for twelve trees. Eight men were employed with the outfit, making an average service of forty minutes of one man's time per tree. Six and seven tenths gallons of emulsion were applied to the average tree, at a total cost of 43 cents for both materials and labor.

In spraying operations, ladders and long canes were used in order that all parts of the larger trees might be reached by the spray. In the greater part of the work 19 and 20 per cent. emulsions of kerosene were applied. To make this up in 200-gallon lots, 20 gallons of water and 27 to 30 pounds of "Tak-a-nap" soap were placed in the mixing tub, and steam was introduced until the soap was dissolved and the solution was boiling hot. Forty gallons of kerosene were then slowly pumped into the tub, and the mixture was pumped back into itself until the kerosene no longer rose to the surface when the pumping ceased. The emulsion was finally diluted by adding hot water to make 200 gallons.

A part of the trees examined were sprayed between December 26 and January 5, and others January 11 and 13 and March 30. The effects of the spray were determined by comparing ratios of dead and living scales on trees which had been treated, with those from others examined at the same time which had received no treatment. A determination of the condition of the scales subsequent to treatment was a much more difficult matter at this season than during the summer. The dormant insects themselves were comparatively large and dense, and changes due to death were produced but slowly in the cold midwinter weather. From twenty-

seven to forty days actually intervened between the time of spraying and the time when the test inspections were made.

It will be sufficient to say, without entering into details, that a critical examination of 13,000 scales taken from 8 trees showed that 86 per cent. of them had been killed by a 19 per cent. emulsion; and an examination of 23,000 scales taken from 11 trees which had been treated with a 20 per cent. emulsion showed that 91 per cent. of these had been killed. Seven trees, two of which had been sprayed January 11 and five March 30 with emulsions containing from 19 to 24 per cent. of kerosene, were examined June 10, 49,000 scales in all being counted, with the result to show that in this case, also, 91 per cent. of those alive when the treatment was applied had been killed by the emulsion. The trees covered by these observations were soft maples, lindens, and honey-locusts, but as the percentages of benefit do not differ materially for these different species they need not be separately given. The following table summarizes these data.

When sprayed	Per cent. of kerosene	Date of counting	Scales counted	Per cent. killed
December 26 to January 5	19	Feb. 1	12,703	86
January 11 to 13	20	Feb. 1-2	23,061	91
January 11 to 13 and March 30	19-24	June 10	48,395	91

INJURY TO TREES.

As one of the results of an examination of trees previously sprayed, made by my inspector June 11 to 13, he reported so serious a damage to some of the trees as to cast doubt on the safety of the kerosene spray. At Graceland Cemetery, for example, some soft maples had received during the winter an experimental treatment with a 25 per cent. kerosene emulsion, evidently prepared in the usual way, and all these trees were in a conspicuously poor condition, with foliage thin, pale, and shriveled, while that of unsprayed trees among them was heavy and dark green. Many of the trees in Lincoln Park on which an emulsion containing 19 or 20 per cent. of kerosene had been used, presented the appearance of a similar, although less serious, injury. A few, indeed, were dead, and dead branches were more numerous on others than usual.

After a study of the report of my own inspector, Mr. E. O. G. Kelly, on the condition of these trees last June, and a full and careful report on the same subject made to Superintendent Warder by Mr. R. W. Braucher, in charge of the spraying operation, and an examination of comparative photographs, made under Mr. Brauch-

er's direction, of trees of various species—some of which had been sprayed and others of which had not—it seems to me clear that many of these trees were already in a more or less enfeebled state owing to the light and sandy soil and other unfavorable conditions affecting their growth, that many treated trees had been further greatly weakened by heavy and continuous infestation by the maple scale, and that the consequences had been in some cases intensified by the action of the kerosene. This is especially suggested by the fact that trees seemingly most injured but not actually killed, presented the same general appearance—though in a more marked degree—as many of those which had not been sprayed at all. Precise and extensive experiments, the results of which may be brought into strict comparison, are needed to show the strength and the amount of the emulsion which it is safe to use under various conditions and on various kinds of trees.

In the meantime, in view of the fact that the thorough spraying of the top of a tall tree in winter requires a large amount of kerosene emulsion, much of which must fall to the earth, and the further well-known fact that fruit-trees may be severely injured, and even killed, by kerosene in the earth about their roots, it will be prudent to protect the ground where this insecticide is used by some impervious or absorbent covering, such as a sheet of canvas or a layer of straw, the latter afterwards to be removed. Kerosene will, in fact, remain effective in the ground for a surprising time, and this fact is the basis of one of its most important uses as a subterranean insecticide.* Thousands of fruit-trees have been destroyed within my own knowledge, by its careful use under the supervision of expert operators, where orchards were undergoing treatment for the San Jose scale.

Experiments already referred to, made at Denver, Col., by Mr. S. A. Johnson, resulted in a way to indicate that weaker emulsions than those used in Chicago may be depended on to destroy the maple scale, as shown by the following table.

Percentage of emulsion	10	12	12½	17	20	25	33	50
November, 1903	88		88		100			100
February, 1904	69	94		99		98	100	100

*The most notable instance of this persistence of kerosene in the earth which has come to my knowledge is reported to me by Professor T. J. Burrill, of the University of Illinois, who, in company with Prof. J. C. Blair, of the Horticultural Department, once lightly sponged the bark of a pear-tree with pure kerosene as an experiment. Nothing unusual was noticed the first year, but the second year the tree was seen to be unthrifty, and the third year it was dead. When dug up to learn the cause of its death, the odor of kerosene was still distinct and strong in the earth among its roots, and especially in the bark about the base of the trunk. The surplus which had run down the surface of the bark and sunk into the soil had remained all this time, acting, no doubt, continuously upon the roots and on the bark of the trunk in a way to kill the tree.

On the strength of these experiments Mr. Johnson recommends an emulsion one sixth of which is kerosene. Trees treated with an emulsion of this strength in the winter of 1904-05 were nearly free from scales the following July, and in January, 1906, only scattering specimens could be found. In view, however, of the difference in climate and the absence of data as to parasitism, these results should not be regarded as conclusive for Illinois.

INSECT ENEMIES.

It is to the insect enemies of the scale rather than to any human agency that the escape of our soft maple trees from complete destruction has hitherto been due. Probably the most effective enemy

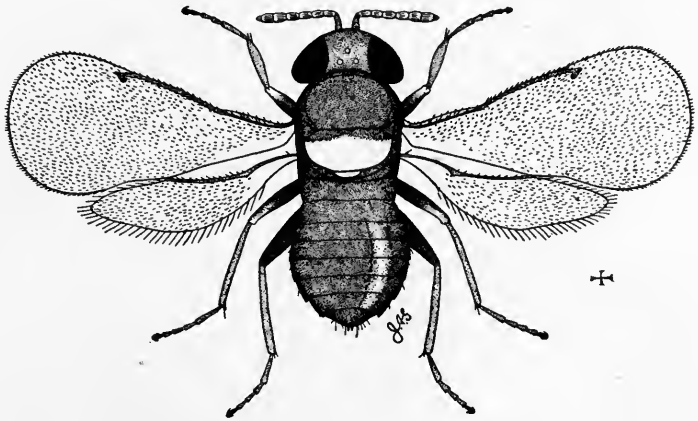


FIG. 6. *Coccophagus lecanii*, adult chalcid parasite of the cottony maple scale. Length, less than $\frac{1}{16}$ inch. (J. B. Smith.)

is a minute black four-winged fly (*Coccophagus lecanii*, Fig. 6) which lays its eggs in the bodies of the young scales. The resulting larva lives as an internal parasite of the insect, develops to the adult, and emerges through a rounded hole cut in the back of the scale. Successive generations follow, and the scale population of a heavily infested tree may be almost completely destroyed in a single season by the parasite. Scales killed by it may be readily recognized by the hole in the back, and by their smaller size as compared with living individuals. Several other related species are known to infest this scale to a less degree.

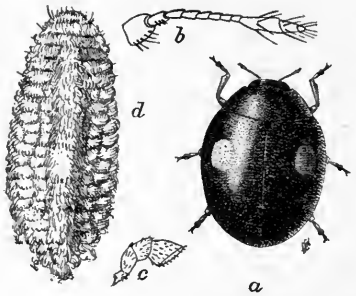


FIG. 7. A Ladybug, *Hyperaspis binotata*, enemy of cottony maple scale: *a*, adult; *d*, larva; *b*, *c*, antenna and palpus of adult. Adult about ½ as long as *Chilocorus bivulnerus*, similarly colored; larva, white. (Sanders, U.S. Department of Agriculture.)

A conspicuous and very efficient enemy is a small hemispherical ladybug (*Hyperaspis binotata,* Fig. 7) about an eighth of an inch long, jet-black, with a small dark-red spot on each side of the middle. It is often seen on the leaves of infested trees and on plants beneath. The white thick-bodied larvæ of this species (Fig. 7, *d*), which feed on the eggs of the scale, may often be found buried in the egg-mass or crawling about on the twigs. The pupa of this ladybug is formed within the cottony egg-mass, and soon changes to the adult. The beetles pass the winter wherever they may find shelter about the tree or on the ground beneath. The larger but similarly-colored "twice-stabbed ladybug" (*Chilocorus bivulnerus,* Fig. 8), with its black spiny larva, also destroys many maple scales.

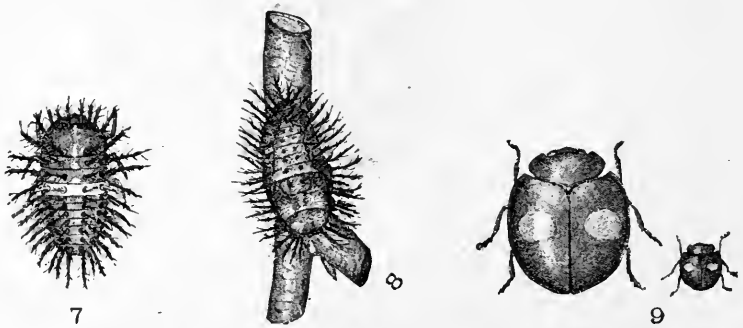


FIG. 8. A Ladybug, *Chilocorus bivulnerus*, larva, pupa, and adult, enemy of cottony maple scale. Natural size indicated at right; color black, adult with two red spots. (Comstock, U. S. Department of Agriculture.)

SUMMARY.

1. Injuries by the cottony maple scale are commonly periodical. A period of destructive abundance and following scarcity extends, on an average, over eight or ten years, the disappearance of the insect being apparently due in the main to depredations by its insect enemies.

2. A partial exception to the foregoing statement is presented by the existing outbreak in northeastern Illinois, and especially in Chicago, where the maple scale has continued injurious for at least six years, and gives no marked present evidence of a general decline in numbers.

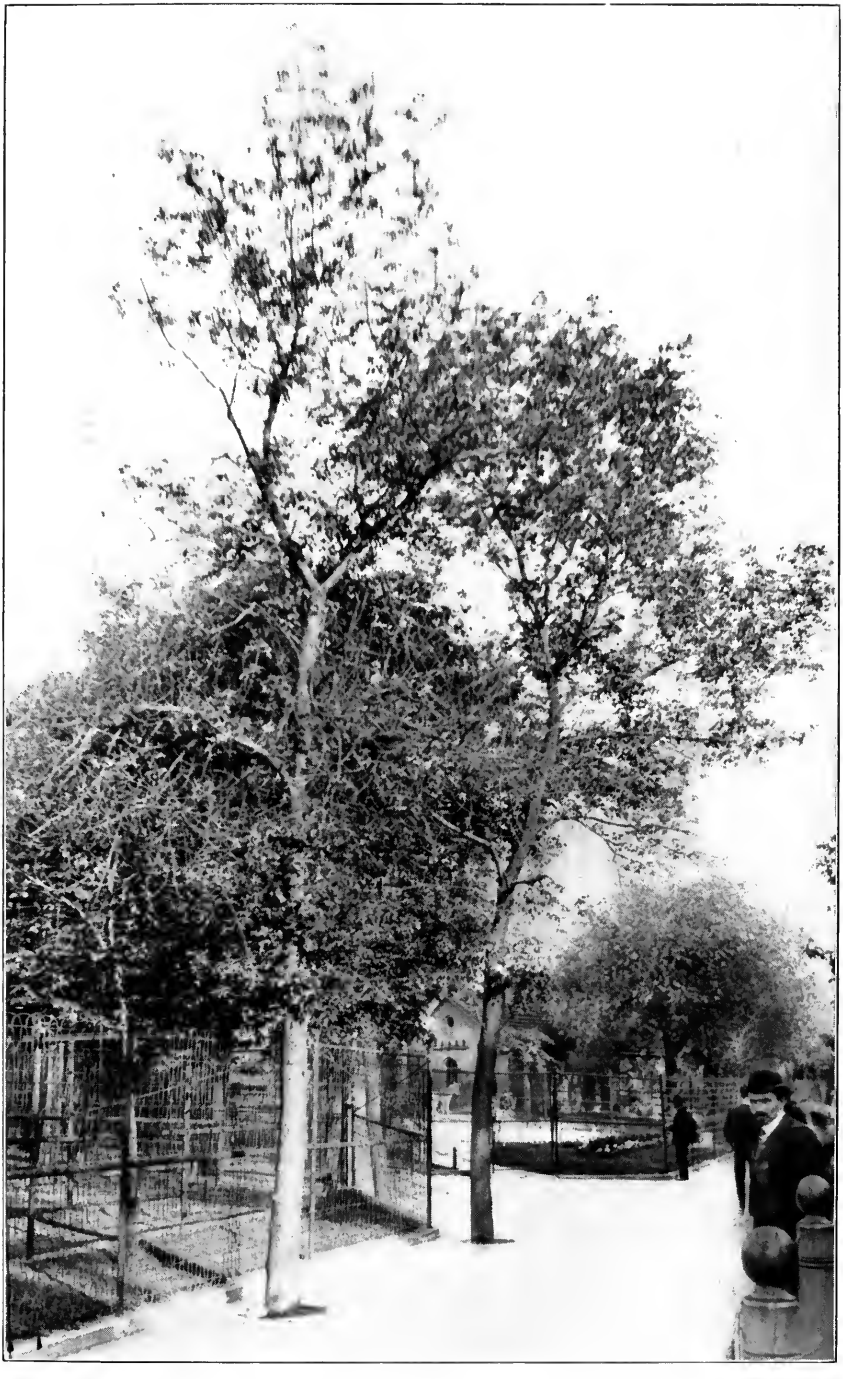


PLATE 3. BOX-ELDER TREES, NOT SPRAYED. PHOTOGRAPHED JUNE 23. WEAK TREES WITH MANY DEAD BRANCHES.

3. The area injuriously infested by this insect in Illinois last year covers parts of at least fifteen counties, distributed throughout the state from the Wisconsin line to Marion county.

4. The chief food plant is the soft maple, but linden and box-elder are almost equally liable to infestation. The elm and the honey-locust are the principal other ornamental trees subject to serious injury.

5. There is but one generation of this insect each year. The females pass the winter partly grown on the twigs of trees, and produce eggs in late May or in June, according to the latitude and the weather of the season. These eggs hatch in June and July, the young insects establishing themselves for the summer on the leaves or twigs, from which they suck the sap. The males emerge as winged insects, and perish at the approach of winter. The females at that time collect on the twigs and smaller branches for hibernation.

6. The most useful insecticide is kerosene emulsion, which, if used in summer, should not contain more than 10, or possibly 12½, per cent. of kerosene, and, if used in winter, not more than 16 to 18 per cent. As a summer spray this emulsion must be used twice in succession, with a ten-day interval between sprayings. The first application must be made when about half the eggs are hatched, and the second at about the end of the hatching period. Two treatments with 10 per cent. kerosene, applied to badly infested trees in Chicago, the first July 11 and the second July 20, 1905, destroyed 82 per cent. of the scales; a single treatment July 11 destroyed 64 per cent.; and one July 19, 68 per cent. A similar treatment July 3, on the other hand, killed but 33 per cent. of the insects.

7. A single treatment in winter with a 19 or 20 per cent. emulsion destroyed more scales than two summer treatments with a 10 per cent. emulsion, the percentages of killed varying from 86 to 91 per cent.

8. Where large trees weakened by unfavorable conditions or by insect attack are treated with strong emulsions in winter, they are liable to injury by a penetration of the kerosene to the roots. Such trees should be protected, consequently, by covering the earth beneath the trees with sheets of canvas or layers of straw, or some similar absorbent substance.

9. Kerosene emulsion is made as follows: Dissolve one pound of common soap, or half a pound of whale-oil soap, in one gallon of water by boiling, remove from the fire, and add two gallons of kerosene. Then with a spray pump force the mixture back into itself for about five minutes, or until it presents the appearance of a thick cream and no longer separates on standing. This is the undiluted

emulsion. For a mixture containing 10 per cent. of kerosene, add seventeen gallons of water to the three gallons thus prepared. For an 18 per cent. kerosene emulsion, add eight gallons of water to the stock solution. Soft water is to be preferred.

10. The principal insect enemies of the cottony maple scale are minute winged parasites which lay their eggs within the bodies of the female parents; and hemispherical shining black ladybugs, each with two red spots on the back, the larvæ of which devour the eggs in spring within the cottony masses beneath the female body.